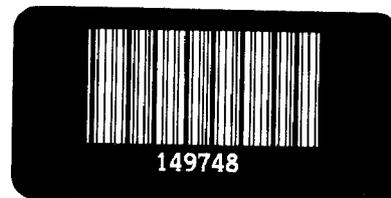


GAO

August 1993

NAVY SHIPS

Problems Continue to Plague the Seawolf Submarine Program



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**National Security and
International Affairs Division**

B-250714

August 4, 1993

The Honorable Edward M. Kennedy
Chairman, Subcommittee on Regional
Defense and Contingency Forces
Committee on Armed Services
United States Senate

The Honorable John Conyers, Jr.
Chairman, Legislation and National
Security Subcommittee
Committee on Government Operations
House of Representatives

This report provides the results of our review of the Navy's Seawolf (SSN-21) Class Nuclear-Powered Attack Submarine construction program. This report discusses (1) the change in the status of the class design and SSN-21 construction since December 1991, (2) the effectiveness of technical and management actions to resolve lead submarine welding problems and guard against a recurrence of a similar problem in the future, and (3) Navy efforts to control schedule delays.

This report covers work we performed and comments we received from May 1992 through June 1993. The official Department of Defense response dated June 24, 1993, notes that program cost increases are largely due to the sharp reduction in the number of submarines that will be procured, which are beyond the program manager's control. (See app. IV.)

As agreed with your staff, we plan no further distribution of this report until 7 days from its issue date. At that time, we will send copies to the Chairmen, Senate Committee on Governmental Affairs, House Committee on Government Operations, Senate and House Committees on Appropriations, and Senate and House Committees on Armed Services; the Director, Office of Management and Budget; and the Secretaries of Defense and the Navy.

If you or your staff have any questions on this report, please call me on (202) 512-3504. Major contributors to this report are listed in appendix V.

Richard Davis
Director, National Security
Analysis

Executive Summary

Purpose

Justification for the Seawolf nuclear-powered attack submarine (SSN-21) and its concurrent design/construction was based on countering the former Soviet Union's submarine force. Almost from the beginning, however, concerns have been voiced about the program's level of concurrency and the submarine's affordability. Over the past 6 years, the program has experienced cost increases, schedule delays, reductions in planned procurements, and proposed termination after construction of the second SSN-21 class submarine.

The Chairmen, Subcommittee on Regional Defense and Contingency Forces, Senate Committee on Armed Services, and the Legislation and National Security Subcommittee, House Committee on Government Operations, asked GAO to (1) monitor the status of SSN-21 class design and lead ship construction, (2) assess the effectiveness of technical and management actions to resolve SSN-21 welding problems and guard against a recurrence of a similar problem in the future, and (3) evaluate Navy actions to keep the program on schedule.

Background

In April 1987, the Navy awarded Newport News Shipbuilding and Dry Dock Company (Newport News Shipbuilding), Newport News, Virginia, a \$303-million (fiscal year 1987 dollars) contract for the overall SSN-21 class design and detailed design of its forward half. As part of its design contract, Newport News Shipbuilding awarded General Dynamic's Electric Boat Division (Electric Boat), Groton, Connecticut, a \$48.8-million subcontract for the detailed design of the submarine's rear half. As of December 1991, Newport News Shipbuilding estimated the total cost of the SSN-21 class design at completion would be \$655 million (current-year dollars)—a \$352-million increase (116 percent) over the original contract cost estimate.

In January 1989, the Navy awarded Electric Boat a \$636.8-million (fiscal year 1987 dollars) contract to build the first SSN-21. Subsequently, Electric Boat estimated escalation would add \$81.2 million to the construction cost, bringing the total estimate to \$718 million. Delivery was originally scheduled for May 1995. Because of welding cracks discovered on the SSN-21's pressure hull in June 1991 and subsequently on other components, the submarine's delivery was delayed 1 year until May 1996. Up until that time, design delays had caused SSN-21 construction to fall significantly behind schedule. In addition, late delivery of its combat system had the potential to further delay the submarine's construction schedule. The 1-year delay tended to abate these problems. However, in

December 1991, Electric Boat estimated the total cost to construct the SSN-21 at \$1,039 million (then-year dollars)—a \$321-million increase (45 percent) over the original contract target cost. These costs do not include the \$1 billion estimated to complete development of the AN/BSY-2 combat system.

Results in Brief

The SSN-21 program continued to experience cost increases and schedule delays during 1992. Since December 1991, the estimated total cost for design and lead ship construction at completion increased about \$28 million and \$64 million, respectively. Design availability and construction work force problems contributed to SSN-21 construction delays. Because of incompatibility between the design and construction schedules, the potential exists for further schedule delays. According to the Navy, however, actions it and Electric Boat have taken are expected to overcome the delays and minimize any effect of the incompatible schedules. Although it is too early to determine whether these actions will be successful, the Navy believes these actions will maintain the SSN-21's May 1996 delivery. SSN-21 welding problems appear to have been resolved and a recurrence is unlikely.

Principal Findings

Corrective Actions Are Expected to Maintain May 1996 Delivery

In the last year (as of December 1992), construction has fallen behind schedule at least 5 months. The Navy and Electric Boat expect that actions they have taken will make up the 5-month delay and minimize the effects of the incompatibility between the design and construction schedules. It is still early in implementation to be sure these actions will be effective.

Electric Boat and the Navy agree that the factors contributing to construction delays include (1) late drawings and other design data, (2) insufficient staff and problems preparing and releasing the instructions and materials needed for construction (work packages), and (3) a smaller-than-expected SSN-21 construction work force. Electric Boat believes that late design data was the primary factor; however, the Navy believes all three factors together caused the delays.

As of December 1992, more than 4,100 (5 percent) of the work packages scheduled for completion and 6,100 (9 percent) of the completed work

packages scheduled for release to construction workers were delinquent. Therefore, to minimize unnecessary construction rework and labor inefficiencies, Electric Boat has not assigned as many construction workers as originally planned. Consequently, the number of construction workers from November 1991 through December 1992 averaged about 38 percent below planned levels. Electric Boat has implemented several measures to address construction delays.

An incompatibility between the design and construction schedules has the potential to further delay the SSN-21's delivery. In March 1991, the design and construction schedules were revised to support a May 1995 delivery, referred to as Revision D. In November 1991, primarily because of the welding problems, a new construction schedule (Revision E) was approved to support a May 1996 delivery. At that time, however, the Navy directed Newport News Shipbuilding to continue its design work to meet the Revision D construction schedule. According to the Navy, the reasons for this directive were to avoid cost increases and staffing changes that a schedule realignment would cause and ensure a schedule margin for design deliveries.

Since November 1991, the design effort has continued to fall further behind the construction schedule. Although the Navy was aware of the problem throughout this time, early corrective actions did not resolve the problem. It was not until the summer of 1992 that the extent of the problem was realized and a detailed analysis was conducted. In December 1992, the Navy directed Newport News Shipbuilding to realign its design effort to support Revision E. According to the SSN-21 program manager, the design and construction schedules are now in line and all design drawing delinquencies will be eliminated by February 1994. In addition, the program manager stated that the corrective actions taken by Electric Boat are expected to maintain the May 1996 delivery. The Department of Defense (DOD) stated that (1) a process to identify the shipbuilder's drawing needs was implemented following adoption of Revision E, (2) the schedule variance did not preclude following the Revision E construction schedule, and (3) overall design progress outweighed the variance problems.

Design and Construction Cost Increases Continue

As of December 1992, Newport News Shipbuilding estimated it would cost \$683 million (current-year dollars) to design the SSN-21 class, a \$28-million (4 percent) increase since December 1991, and \$380 million (125 percent) over the original contract cost estimate. According to Newport News

Shipbuilding officials, cost increases are primarily due to contract modifications; expanded work scope; and increased labor, material, and overhead rates.

In December 1992, Electric Boat estimated SSN-21 total construction costs would increase to \$1,103 million (then-year dollars), a \$64-million (6 percent) increase since December 1991, and \$385 million (54 percent) over the initial cost estimate to complete construction. The \$385 million includes an estimated \$173 million in escalation, which is a \$91.8-million increase over Electric Boat's initial \$81.2-million estimate. According to Electric Boat officials, cost increases are primarily due to changes in specifications, reductions in the number of submarines to be constructed, which results in higher overhead costs per submarine, and re-estimation of construction elements unknown during the bid proposal and at contract award.

The SSN-21 program also will incur additional cost increases because of design and construction schedule incompatibility. Although the full impact is being studied, the SSN-21 program manager believes the cost increases will be minimal.

Welding Problem Resolved

By September 1992, Electric Boat had corrected the welding problem and instituted new procedures that included raising preheat and post-weld temperatures, increasing the heating time for completed welds to "burn off" impurities, and using welding wire containing less carbon. Electric Boat and Navy officials and three welding consultants GAO contacted believe that the new welding procedures have resolved the welding problem and should prevent any recurrence.

Recommendations

This report contains no recommendations.

Agency Comments

DOD generally agreed with GAO's findings on the status of the SSN-21 design and lead ship construction program and provided additional comments, which GAO has incorporated where appropriate. (See app. IV.)

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Abbreviations

DOD Department of Defense

Introduction

The Navy justified the Seawolf (SSN-21) class nuclear-powered submarine program and concurrent design/construction of the lead submarine as necessary to counter the former Soviet Union's new generation of quieter, more capable submarines. The SSN-21 class, designed to be quieter, deeper diving, and tactically faster, will provide better operational and weapons capability than the Navy's Los Angeles (SSN-688) class nuclear-powered attack submarines currently under construction.

Due to the collapse of the Soviet Union, as well as U.S. defense budget constraints, planned procurement of SSN-21 class submarines has been reduced from 29 to 2. Unless the Clinton administration seeks funding to build additional SSN-21 class submarines, the program will terminate after the SSN-22 is built.¹

Total Program Costs Decrease While Average Submarine Costs Increase

Although construction of only two SSN-21 class submarines reduced total estimated program costs by more than \$33 billion,² the average submarine cost has increased by 247 percent. Table 1.1 details the effect procurement reductions have had on total and average costs for the SSN-21 program.

Table 1.1: Changes in SSN-21 Development and Procurement Cost Estimates

Dollars in billions

Year	Number of ship	Research, development, test, and evaluation	Procurement	Total	Average cost
1985	29	\$2.7	\$41.0	\$43.7	\$1.5
1991	12	5.0	28.5	33.5	2.8
1992	2	4.6	5.8	10.4 ^a	5.2

^aAccording to the Navy, this includes actions it is taking to avoid future program costs of about \$208 million over the life of the SSN-21 program. These actions include reducing the number of construction spares and canceling the HY-130 steel program.

¹In January 1992, President Bush announced plans to terminate the program and proposed rescinding appropriated funds and canceling planned spending for all SSN-21 class submarines, except the lead submarine. Subsequently, in March 1992, Congress debated the merits of building one, two, or three SSN-21 class submarines. This debate culminated in Public Law 102-298, "An Act Rescinding Certain Budget Authority," Fiscal Year 1992, June 4, 1992, which implicitly rejected the administration's rescission proposal and, among other actions, restored funding to construct the SSN-22.

²Unless otherwise designated, all cost data is expressed in then-year dollars.

SSN-22 Construction

On May 3, 1991, the Navy awarded General Dynamics' Electric Boat Division (Electric Boat), Groton, Connecticut, a fixed-price incentive-fee contract to construct the SSN-22 at a cost of \$689 million. The Newport News Shipbuilding and Drydock Company (Newport News Shipbuilding), Newport News, Virginia, challenged the contract award in court, but the U.S. Circuit Court of Appeals, Richmond, Virginia, upheld the Navy's contract award to Electric Boat on March 16, 1992. However, the Navy had placed a stop work order on this contract due to the Bush administration's decision to terminate the SSN-21 program after constructing the lead ship. The stop work order was lifted in June 1992. Electric Boat began SSN-22 construction in September 1992, with contract delivery scheduled for June 1997. Primarily because of construction start delays, but also because of the court challenge and a Navy stop work order, Electric Boat requested a \$124-million (1987 dollars) increase in the SSN-22 contract's target cost and an 18-month delivery date extension (to December 1998). The Navy expects to decide on Electric Boat's request in late July 1993.

Cancellation of SSN-23 Through SSN-26 Contracts

In fiscal year 1991, Congress appropriated \$2.4 billion to construct the SSN-23 and cover advanced procurement items for follow-on SSN-21 class submarines. Until President Bush proposed terminating the program in 1992, the Navy had planned to issue a solicitation for SSN-23 construction during the second quarter of fiscal year 1992. Since then, however, Congress has rescinded certain funds appropriated for SSN-23 through SSN-26,³ and the Navy has either completed, issued stop work orders on, or terminated related contracts.

Our Prior Reviews of SSN-21 Related Issues

Since 1985, we have reported 19 times on a wide range of SSN-21 program-related issues. (See app. I.) Topics have included affordability and concurrency, combat system development risks, cost increases and schedule delays, propulsor development and testing, and the effect of reduced SSN-21 class submarine procurement on the U.S. submarine shipbuilding industry. In our last report,⁴ we discussed the SSN-21 program's status as of December 1991 and pointed out that design and construction problems have caused continued cost increases and schedule delays. This report presents the results of our continuing SSN-21 program

³For a full discussion on the Bush administration's rescission proposal and the resulting Public Law 102-298, see GAO's report, *Navy Ships: Plans and Anticipated Liabilities to Terminate SSN-21 Program Contracts* (GAO/NSIAD-93-32BR, Nov. 27, 1992).

⁴*Navy Ships: Status of SSN-21 Design and Lead Ship Construction Program* (GAO/NSIAD-93-34, Nov. 1992).

work and provides a 1-year snapshot of the program's status as of December 1992.

Objectives, Scope, and Methodology

The Chairmen, Subcommittee on Regional Defense and Contingency Forces, Senate Committee on Armed Services, and the Legislation and National Security Subcommittee, House Committee on Government Operations, asked us to (1) monitor the status of SSN-21 class design and lead ship construction, (2) assess the effectiveness of technical and management actions to resolve lead ship welding problems and guard against a recurrence of a similar problem in the future, and (3) evaluate Navy efforts to control schedule delays.

To accomplish our overall objectives, we reviewed and analyzed Navy studies; Navy assessments; and contractor cost, schedule, performance, and staffing reports. We also held discussions with Navy officials responsible for the class design, SSN-21 construction, and subsystems' development in Washington, D.C., and at other locations identified below.

To determine the status of the class design, we reviewed and analyzed contractor-developed documents and reports and held discussions with officials at Newport News Shipbuilding; officials of the SSN-21 program within the Naval Sea Systems Command, Arlington, Virginia; and the Navy's Office of the Supervisor of Shipbuilding, Conversion, and Repair, Newport News, Virginia.

To determine the status of SSN-21 construction, we held discussions with officials from Electric Boat and the Office of the Supervisor of Shipbuilding, Conversion, and Repair, Groton, Connecticut, and the SSN-21 program office. In addition, we determined the status of major SSN-21 subsystems to determine whether they will negatively affect the SSN-21 construction schedule. Based on our prior SSN-21 program work, we selected 10 major SSN-21 subsystems to review. We also discussed the development of these subsystems with responsible Navy officials. Of the 10 subsystems we examined, 2 are experiencing design, production, or installation schedule problems but are not expected to affect SSN-21 construction. These two subsystems and the AN/BSY-2 combat system are discussed in appendix II.

To assess the effectiveness of technical and management actions to correct SSN-21 welding deficiencies, we held discussions with officials from Electric Boat, the Navy's Office of the Supervisor of Shipbuilding,

Conversion, and Repair, Groton, Connecticut; the SSN-21 program office; the Naval Sea Systems Command Office of Ship Design and Engineering; the Office of the Naval Nuclear Propulsion Program; and three welding consultants hired by the Navy. We also reviewed contractor and Navy welding test sampling and quality assurance reports. (See app. III for a full discussion.)

We discussed the Navy's effort to control schedule delays with representatives of the SSN-21 program office, but primarily with the Navy's on-site Supervisor of Shipbuilding, Conversion, and Repair, Groton, Connecticut, for SSN-21 construction and the Supervisor of Shipbuilding, Conversion, and Repair, Newport News, Virginia, for SSN-21 class design.

We conducted our review between May 1992 and May 1993 in accordance with generally accepted government auditing standards.

Design and Construction Problems Continue

During the past year, the SSN-21 class design and lead submarine construction efforts have continued to suffer schedule problems. The major factors contributing to the construction delays are late delivery of design data, delays preparing and releasing work packages (including late receipt of material on hand or on order), and a smaller-than-planned construction work force. These problems, combined with a variance between the design and construction schedules, have the potential to delay the SSN-21's May 1996 delivery. According to the SSN-21 program manager, based on Electric Boat's plans to address schedule delays, the SSN-21 should still be delivered in May 1996.

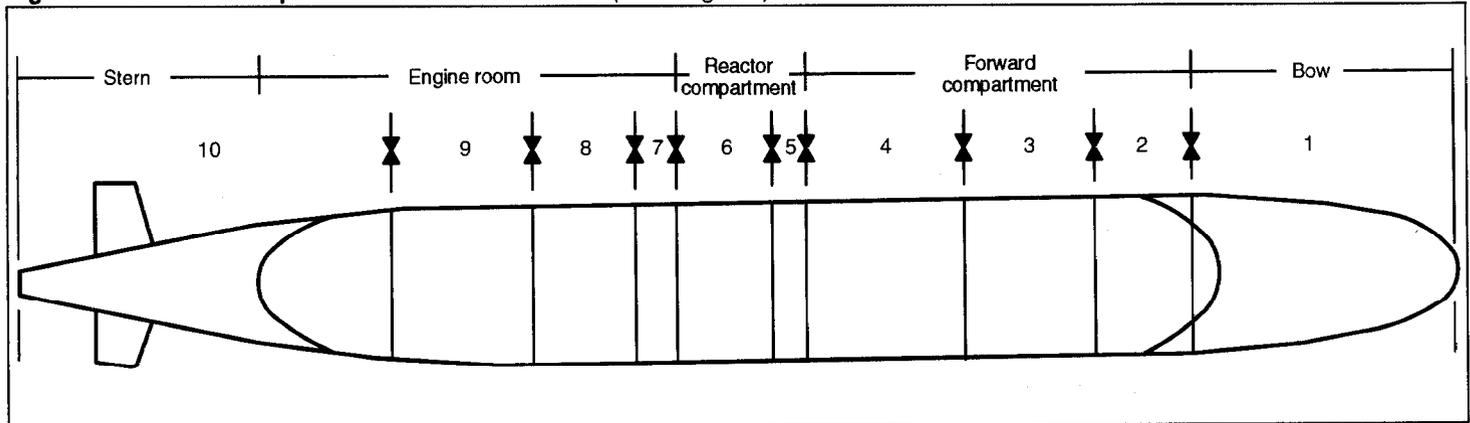
SSN-21 Construction Behind Schedule

As of December 1992, SSN-21 construction had fallen behind the schedule established to meet the revised May 1996 delivery. Although all 10 hull sections were under various stages of construction, the reactor compartment (hull sections 5, 6, and 7) was 7 weeks behind schedule; the forward compartment to the submarine's bow (hull sections 1, 2, 3, and 4, and the sail) was 20 weeks behind schedule; and the engine room to the stern (hull sections 8, 9, and 10) was about 16 weeks behind schedule.¹ While Electric Boat estimated that construction delays amounted to about 5 months, the Navy estimated the delay at 6 months.² Figure 2.1 illustrates the submarine's hull.

¹As of December 1992, construction of the SSN-21 was 38 percent complete versus a planned 44 percent.

²According to a Supervisor of Shipbuilder (Groton) assessment of Electric Boat's direct labor hours estimate, as of the end of February 1993, SSN-21 construction was 7 months behind schedule.

Figure 2.1: SSN-21 Compartments and Hull Sections (1 Through 10)



Electric Boat believes the primary reason for SSN-21 construction delays was due to the design effort not fully supporting the construction schedule. Since October 1989, when construction started, the construction schedule has changed four times. The last two changes occurred in March 1991 (Revision D) and November 1991 (Revision E). Revision E, the current construction schedule, changed the submarine's delivery from May 1995 to May 1996.

Electric Boat has expressed its concerns to the Navy about the effects of late design data a number of times. For example, in its June 1992 cost report to the SSN-21 program office, Electric Boat reported that work package preparation and construction were delayed by late receipt of design data. In its September 1992 cost report issued in November 1992, Electric Boat reported to the Navy that late design data had become a significant contributor to construction delays. According to its report, in October 1992, Electric Boat sent letters to the SSN-21 program office listing construction schedule requirements for unissued drawings. The letters requested that the government provide the estimated issue dates for these drawings so the company could produce realistic detailed construction schedules. Finally, in a November 1992 letter to the Supervisor of Shipbuilding, Groton, Connecticut, Electric Boat stated that "the late, frequently changing and incomplete [SSN-21] design has impacted our [Electric Boat's] ability to order and receive material, release work packages, and fully process/fabricate the work in an efficient manner."

In letters to the SSN-21 program manager (dated September 23 and December 23, 1992) regarding Electric Boat's June 1992 and September 1992 cost reports, the Supervisor of Shipbuilding, Groton, Connecticut, stated that although late design data existed, it was not the principal factor for overall schedule delays. Other factors contributing to construction delays included problems preparing and releasing work packages and a smaller-than-planned work force constructing the SSN-21. He stated, however, that as Electric Boat overcomes these production process problems, the lack of design data will become a more prominent factor. In addition, according to the December letter, the shipbuilder has not, in all cases, performed work on items for which design data existed and construction problems, such as ripping out and redoing construction work, have also contributed to schedule delays.

Work Package Preparation Delays

Electric Boat has experienced delays preparing and releasing work packages (instructions and materials needed for construction) needed to start construction and support the Revision E construction schedule. Preparation problems resulted from insufficient staff, while late release of completed work packages resulted from a processing problem.

Electric Boat has taken several measures to improve the timely development of work packages. For example, Electric Boat increased its work package preparation staff from 53 people to 78 people through transfers from the SSN-688 construction program and planning department, provided 35 percent overtime for 2-1/2 months, and provided 17 additional computer terminals. These measures were primarily responsible for reducing delinquencies from 12 percent in August 1992 to 5 percent by December 1992, as shown in table 2.1.

Table 2.1: Delinquent Work Packages Prepared by Certain Dates

Date	Scheduled to be completed	Actually completed on schedule	Delinquent	Percent delinquent
6/13/92	46,935	41,445	5,490	12
8/22/92	62,150	54,629	7,521	12
10/31/92	69,069	64,872	4,197	6
11/28/92	71,240	67,339	3,901	6
12/30/92	75,466	71,345	4,121	5

In addition to problems developing work packages, Electric Boat had problems releasing thousands of completed work packages³ to construction workers on schedule resulting in construction delays. (See table 2.2.) The primary reason for the high delinquency rate was that, under the original manufacturing resource plan, completed work packages would not be released until all elements of the work package were available. To address this problem, Electric Boat modified the system so that, for example, if one piece of material was not available because it had not been delivered by a vendor or was still in the manufacturing process, the work package was released so that other work could be started. The missing material component would be installed when it becomes available. This action is the primary reason for improved work package release rates.

Table 2.2: Work Packages Released Late

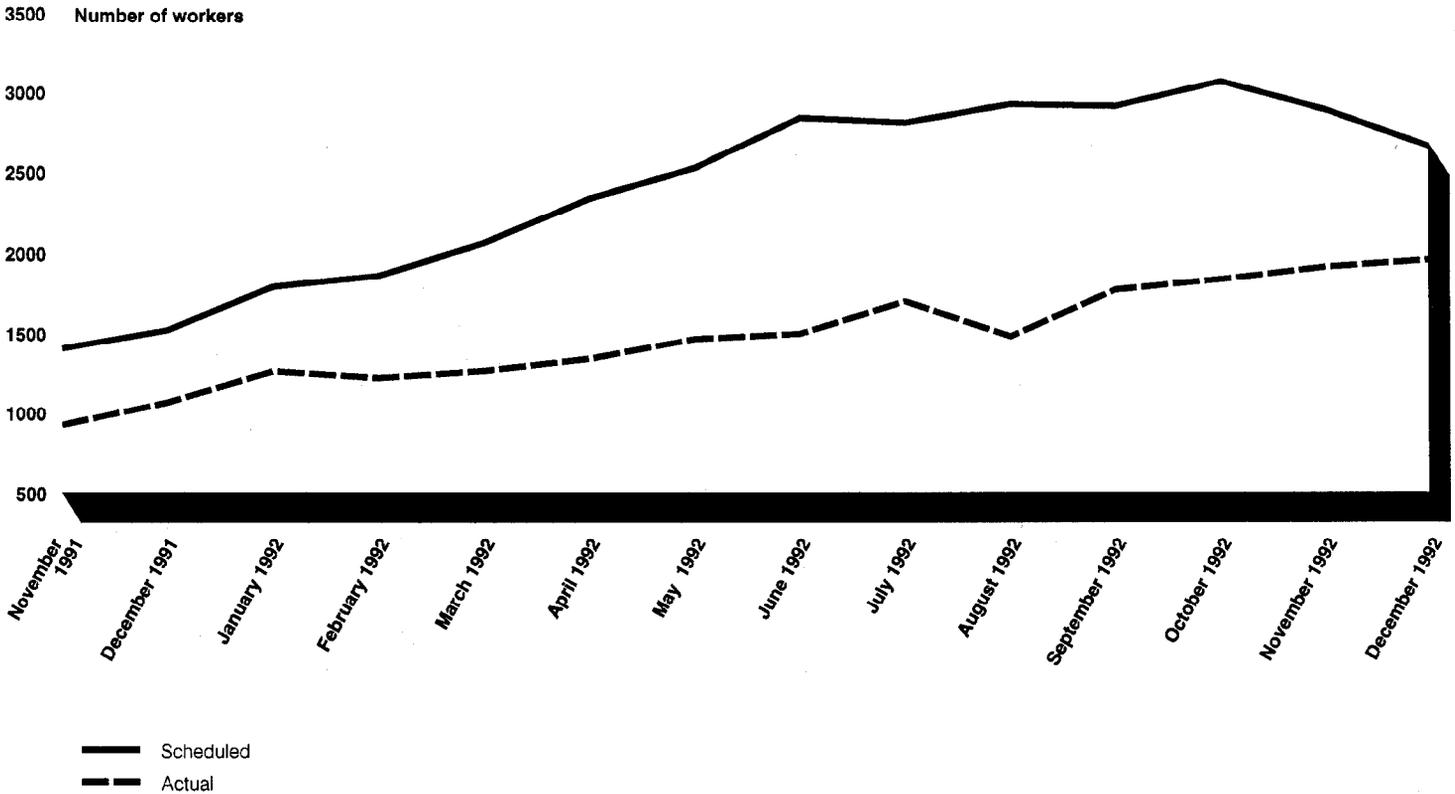
Date	Work packages scheduled for release	Work packages released on schedule	Delinquent work packages	Percent of total delinquent
12/21/91	14,404	11,515	2,889	20
3/31/92	19,872	14,837	5,035	25
6/29/92	39,268	27,655	11,613	30
9/26/92	47,173	41,711	5,461	12
12/30/92	66,021	59,910	6,111	9

Insufficient Number of Construction Workers

The size of the SSN-21 construction work force has consistently been smaller than planned under the Revision E construction schedule and has caused less work to be performed. Since November 1991 (when the Revision E construction schedule was approved) through December 1992, the understaffing percentages have ranged between a high of 49 percent (August 1992) and a low of 26 percent (December 1992), for an average of 38 percent over this period. (See fig. 2.2.)

³After a work package is developed and before its release, the work package is converted from the computer format into hard copy, the work is scheduled, and the availability of materials is ensured.

Figure 2.2: Comparison of Scheduled to Actual Workers Constructing the SSN-21



Since as early as June 1992, the Navy has been concerned with the construction work force's size. In addition to informing Electric Boat of its concerns during regular meetings, program documentation shows that the Navy has continually requested Electric Boat to discuss differences between planned and actual construction work force levels, the reasons for not meeting planned levels, and planned corrective actions to ensure the SSN-21 is delivered on schedule. Subsequently, in October 1992, after several meetings with Electric Boat officials, the Navy's Supervisor of Shipbuilding concluded in a letter to Electric Boat that (1) since May 1992, all staffing recovery commitments have fallen well short of stopping schedule delays, let alone recovering from schedule delinquencies, and (2) the SSN-21 would not be delivered on schedule if the shipbuilder continued to understaff construction.

According to Electric Boat's SSN-21 program manager, the primary reason for a smaller-than-planned construction work force has been the unavailability of required design data. As Electric Boat has reduced work package delinquencies, he said, it became obvious that (1) the receipt of design drawings was not supporting planned work force levels, (2) Electric Boat could not implement its plan to correct understaffing by the end of 1992 because of late design data, and (3) Electric Boat commits construction personnel only to work where the requisite design data and material are available to minimize unnecessary rework and labor inefficiencies. In commenting on our draft report, the Department of Defense (DOD) stated that other factors affecting the work force level include material availability, work package procedures, and workers on other ships under construction. Nevertheless, DOD asserts that sufficient personnel are available to complete the SSN-21 on schedule.

Since December 1992, the SSN-21 construction work force has been smaller than planned. For example, during January and February 1993, Electric Boat's weekly average plan required 1,586 workers. However, the actual weekly average size of the work force was about 820 people, or about 47 percent less than planned.

In March 1993, Electric Boat issued Revision E-10 to the SSN-21 master construction schedule. According to Electric Boat and the Supervisor of Shipbuilding (Groton), this revision maintains the May 1996 delivery by resequencing the SSN-21's volatile hull erection schedule. They further stated that the impact of resequencing the hull schedule allows more time at Electric Boat's Quonset Point facility to outfit module/sections. The Supervisor of Shipbuilding's initial analysis of Revision E-10 showed that sufficient trade workers existed at Quonset Point to meet requirements for all submarines under construction, including the SSN-21, by working 10 to 20 percent overtime. The Supervisor of Shipbuilding further noted, however, that although the SSN-21 Revision E-10 schedule contained no slack, during the first 2 weeks of the plan, the SSN-21 was understaffed by an average of 25 percent.

Incompatibility Between Design and Construction Schedules

The use of modular construction techniques and processes in shipbuilding requires that detailed design data and construction drawings be issued in a sequence and by established dates that support modular construction, fabrication, and assembly plans. As a result, the timely issuance of required design data is critical and any change in design can affect construction.

An incompatibility between the design and construction schedules has the potential to cause further design and construction delays. Since November 1991, the design effort has been directed toward meeting the Revision D construction schedule, while the construction effort was directed toward meeting the current Revision E construction schedule. In commenting on our November 1992 SSN-21 status report, DOD stated that the SSN-21 program manager's decision to require the design effort to follow Revision D was made to avoid staffing level changes and cost increases that would have resulted from a schedule realignment. At that time, it was also assumed that a design effort held to an earlier SSN-21 delivery date (May 1995) would ensure a schedule margin for design deliveries and support a construction delivery date that was 1 year later (May 1996). To monitor the incompatibility between the design drawing and construction schedules, the Navy and Electric Boat developed a monthly late and urgent drawing list. According to the Navy, this urgent drawing list then became an important tool for controlling the issuance of design data.

According to the Navy, the construction sequence under Revision D was similar to the construction sequence under Revision E and also supports the Revision E construction schedule. The Navy monitored the two efforts to ensure that design data supported construction. However, by March 1992, it became evident that design data was not being provided in time to fully support every modular construction activity and actions were taken to correct the problem (i.e., increasing management overview and conducting monthly planning meetings with all participants). Several months later the problem remained, causing the Navy to conduct more intensive reviews. For example, to fully support the construction schedule, the Navy conducted detailed reviews of design and construction at the module level. Although there were no differences between the construction sequence of Revision D and Revision E master construction schedules at the section level, the issuance of design data was not fully supporting all construction efforts at the modular or subassembly levels.

In December 1992, the SSN-21 program manager directed Newport News Shipbuilding to bring its design effort in line with the Revision E construction schedule. In February 1993, a preliminary assessment by Newport News Shipbuilding design officials showed the following: (1) 110 initial issue drawings and more than 473 revised drawings were behind schedule; (2) realigning the design effort to meet the Revision E construction still may not support construction because work continues to be resequenced; (3) design staff levels were increased and will remain

higher than planned for the remainder of fiscal year 1993, after which Newport News Shipbuilding plans to accelerate staffing reductions; and (4) some design efforts in progress may be halted while others that are now considered to be ahead of schedule, for efficiency reasons, may be completed early. The Navy estimates that it will take until February 1994 before delinquent design drawings are eliminated.

Representatives from the SSN-21 program office and the Offices of the Supervisor of Shipbuilding at Electric Boat and Newport News Shipbuilding stated that the primary responsibility for ensuring the compatibility between the design and construction schedules rested with the SSN-21 program office. The potential impact of the incompatibility was identified in summer 1992. However, the decision to bring the two schedules in line was not made until December 1992. The intervening time was needed to analyze the problem and take appropriate actions.

Actions to Deliver the SSN-21 on Schedule

Actions have been taken to specifically overcome the construction delays, prevent any future schedule delays, and minimize the effects of the incompatible schedules. In September 1992, Electric Boat implemented various actions to overcome the 5-month construction delay and meet the May 1996 delivery date. Also, Electric Boat changed the construction sequence affecting four sections of the SSN-21 to lessen the impact on major construction milestones.

In addition, Electric Boat implemented several additional measures to overcome construction delays, such as

- working 3 shifts, 7 days a week, on critical path items;
- working 48 hours a week for trade workers and support personnel; and
- recalling 144 workers and hiring 58 new workers, beginning in January 1993.

According to the SSN-21 program manager, both the Navy and Electric Boat are taking actions to minimize the effects of the schedule incompatibility. These actions include (1) increased interaction between the design and construction efforts by creating a Newport News Shipbuilding presence at Electric Boat, (2) more aggressive program office management through the use of progress reviews (at a minimum on a quarterly basis but more frequently if needed), and (3) more aggressive monitoring of the design and construction schedules. The program manager also stated that Electric Boat is reworking its construction

schedule to increase the amount of construction work at its Quonset Point facility. According to the program manager, this change will allow some functions—that is, component/system testing, greater amount of hull section outfitting, and installation of propulsion plant components—to be performed earlier and concurrently rather than sequentially. As a result, the SSN-21 program manager believes the SSN-21's May 1996 delivery schedule will be maintained.

Conclusions

The trend of class design and SSN-21 construction schedule delays continues. Furthermore, the incompatibility that existed between the design and construction schedules has the potential to cause further schedule delays. Compatibility between the design and construction efforts is critical because modular construction requires that detailed design data be issued in the order and by the time needed by the shipbuilder. Any changes to either effort can affect the other. Therefore, it is incumbent upon the Navy to make sure that design and construction efforts are compatible.

When the Revision E construction schedule was approved in November 1991 to meet a May 1996 delivery, the SSN-21 program manager decided that the design effort would be held to the Revision D construction schedule. He elected to follow the previous Revision D construction schedule for the design effort to maintain the existing manning and cost profiles. This decision was expected to achieve a schedule margin for delivering design data to the shipbuilder, but the margin never materialized. The Navy and shipbuilder have taken actions to overcome construction delays and minimize the effects of incompatible schedules. Although Navy and Electric Boat officials believe that these actions are expected to maintain the May 1996 delivery date, we believe it is still too early to determine whether the initiatives will be successful or the trend of schedule delays will continue.

Design and Construction Costs Continue to Increase

The cost of designing and building SSN-21 class submarines continues to increase. Between December 1991 and December 1992, design costs increased 4 percent and construction costs increased 6 percent. When completed, design costs will have more than doubled and construction costs will have increased by 54 percent over original estimated contract costs.

Design Costs Will More Than Double

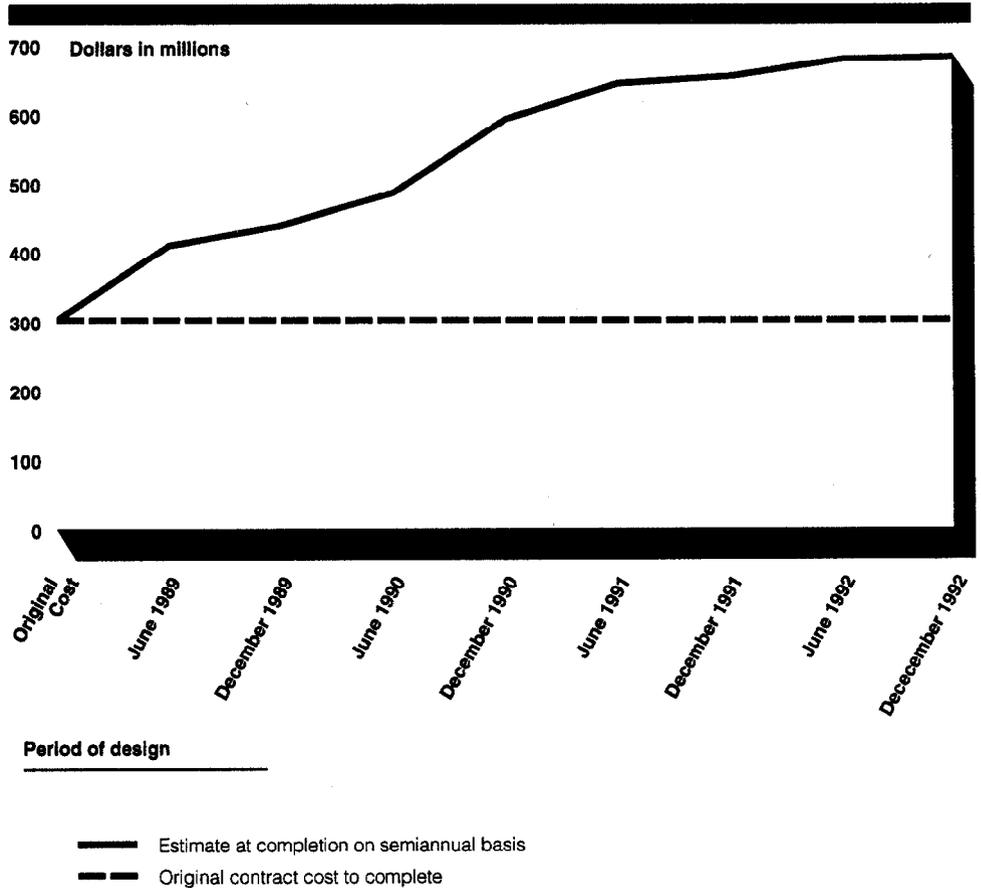
In April 1987, the Navy awarded Newport News Shipbuilding a \$303-million (fiscal year 1987 dollars) cost-plus-fixed-fee contract for overall SSN-21 class design and detailed design of its forward half. As part of its design contract, Newport News Shipbuilding awarded Electric Boat a \$48.8-million cost-plus-fixed-fee subcontract¹ for the detailed design of the submarine's rear half. Since award of these contracts, design costs have increased dramatically. As of December 1992, Newport News Shipbuilding estimated that the total cost of the design is expected to be about \$683 million when completed. This represents a \$28-million (4 percent) increase since December 1991 and \$380 million (125 percent) over the original \$303 million contract cost estimate. (See fig. 3.1.) The estimate includes \$162 million to complete Electric Boat's design effort (a \$5.1-million increase over the December 1991 estimate and \$114 million over the original subcontract cost estimate).

In commenting on this report, DOD stated that the SSN-21 program office baselined the detail design contract on June 20, 1990, and, as a result, the comparisons used in this report do not represent the current contractual agreement with Newport News Shipbuilding. Relative to the rebaselined contract, the current estimated cost of \$649.5 million (current-year dollars) represents a 22-percent increase.

While we recognize that subsequent events often require that changes be made to contracts and related estimates, we believe that comparing current cost estimates to the original cost estimates provides an insight into the events that are influencing the program and the trend of the program.

¹An additional \$4.3 million represents the fixed-fee portion of this contract.

Figure 3.1: Comparison of Original SSN-21 Design Target Cost to Estimate-at-Completion (Current-Year Dollars)



Source: Newport News Shipbuilding cost reports.

According to the Navy, three factors have caused most of the cost increase: (1) the unexpected complexity of incorporating modular construction concepts into the design, (2) two shipyards concurrently designing the SSN-21 class, and (3) implementation of advanced computer-aided design methods for modular construction. Three additional factors contributing to cost increases are specification changes, increased labor hours, and incompatible design and construction schedules. Under the terms of the contract, the government will pay Newport News Shipbuilding for all allowable cost increases, plus a fixed fee.

First, by September 1992, the Navy approved more than 800 specification changes that it said were needed to complete the design. According to program office officials, only 30 of these changes were needed to meet quieting and noise reduction requirements. These 800 changes increased design costs by almost \$180 million.

Second, Newport News Shipbuilding has increased the number of labor hours needed to design the SSN-21 class by 50 percent since contract award. During contract negotiations and prior to contract award, the Navy and Newport News Shipbuilding agreed that the design effort would require an estimated 7.2 million labor hours at a cost of \$102 million. After better defining the design requirements; the production process; and the submarine's weight, noise, and shock requirements, the Navy expanded the scope of work to be performed and increased the estimate to 10 million labor hours. By the end of September 1992, Newport News Shipbuilding further increased its labor hours estimate to 12.3 million hours (an increase of about 1,106 staff years) at an additional cost of \$85 million.

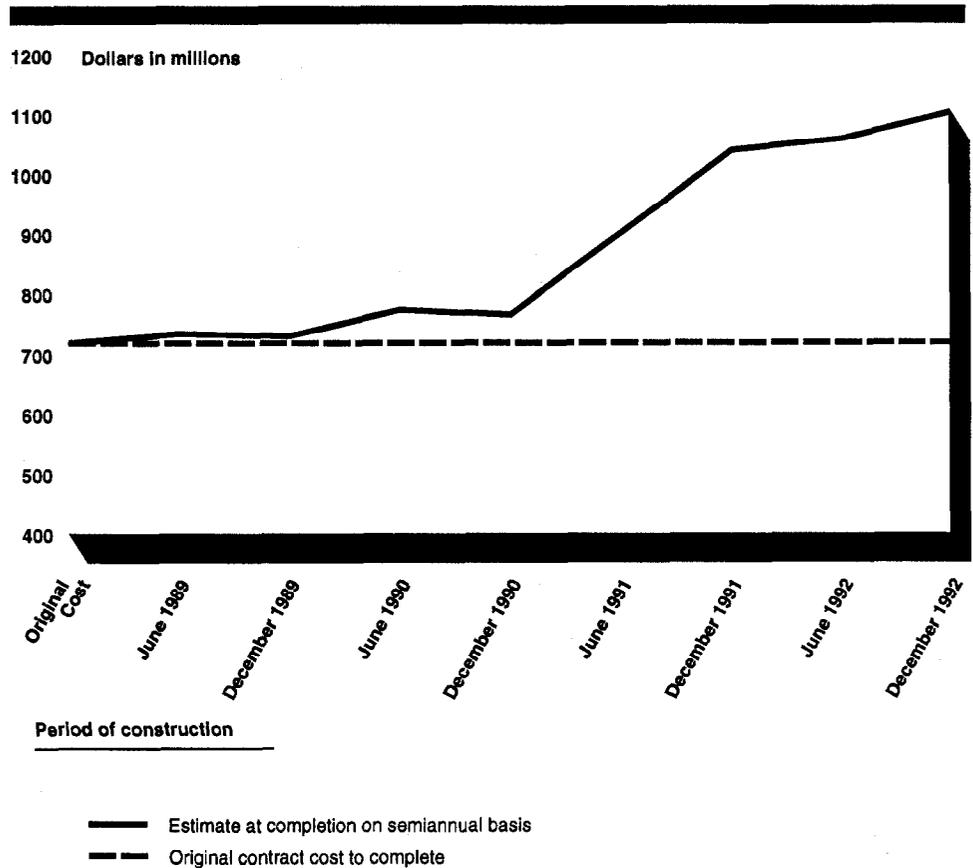
The third factor, the incompatibility between the design and construction schedules, as discussed in chapter 2, will result in additional design cost increases. Newport News Shipbuilding and the Navy are assessing the cost impact to correct this problem. According to the SSN-21 program manager, although some cost increases are expected to correct the incompatibility, no increases in the total number of hours needed to design the class are expected.

Construction Costs Will Increase More Than 50 Percent

In January 1989, the Navy awarded Electric Boat a contract to construct the first SSN-21 with a target cost of \$636.8 million (fiscal year 1987 dollars). The cost to complete construction increased to \$718 million (then-year dollars) when Electric Boat's November 1988 estimate of \$81.2 million for escalation is added to the target cost. Since then, construction costs have increased significantly. As of December 1992, Electric Boat estimated that the total cost of SSN-21 construction will rise to about \$1,103 million—a \$64-million (6 percent) increase since December 1991 and a \$385-million (54 percent) increase over the original contract cost estimate. (See fig. 3.2.) The \$385-million projected increase at completion of construction includes \$173 million in escalation, a \$91.8-million increase over Electric Boat's initial \$81.2 million estimate. DOD stated that over half of the projected increase is due to the cancellation of the program and the impact of stop work orders.

Further increases are likely as work progresses. On March 24, 1993, Electric Boat submitted an \$18.4-million request for equitable adjustment to the Navy. Electric Boat believes it is entitled to an adjustment because of late and unsuitable government-furnished design data. The Navy is evaluating this request.

Figure 3.2: Comparison of Original SSN-21 Construction Target Cost to Estimate-at-Completion (Then-Year Dollars)



Source: Electric Boat cost reports.

The \$64-million increase since December 1991 consists of \$15 million for contract changes, \$30 million for increased labor rates, and \$19 million for increases in material cost estimates at completion. Table 3.1 shows the major factors contributing to the \$385-million increase.

**Chapter 3
Design and Construction Costs Continue to
Increase**

**Table 3.1: Factors Contributing to
Increased Construction Costs**

Estimated increase	Major factors
\$154 million	Changes in Navy specifications, the largest of which is associated with correcting the HY-100 welding problem.
\$182 million	Increased labor rates and vendor material costs; allocation of management cost to 2 SSN-21 submarines rather than 29; and the impact of the court-imposed stop work order on the SSN-22 schedule.
\$49 million	Re-estimation of construction elements unknown during the bid proposal and at contract award, and construction cost overruns.

Summary of SSN-21 GAO Related Products

Since 1985, GAO has issued 19 SSN-21-related products.

- A November 4, 1985, report discussed development problems that could adversely affect the Navy's attack submarine programs, Navy Acquisition: SUBACS Problems May Adversely Affect Navy Attack Submarine Program (GAO/NSIAD-86-12).
- A March 24, 1987, testimony on the SSN-21 and AN/BSY-2 programs expressed concerns about SSN-21 affordability, concurrency, and the potential effects of concurrency on modular construction, Status of the Navy's New Seawolf Attack Submarine and Its New Combat System (GAO/T-NSIAD-87-14).
- An April 28, 1987, letter to Senator John Warner compared similarities between the SSN-21's combat system and the B-1B's avionics system programs. We concluded that when production drives the development schedules of critical state-of-the-art subsystems, technical problems identified during development testing typically affect program cost, schedule, and performance.
- A February 27, 1989, letter provided a legal opinion that 10 U.S.C. 138 (Supp. IV 1986), subsections (b)(5) and (f)(2) require actual operational testing and evaluation, not simply "early operational assessments," before a major defense acquisition program can proceed beyond low-rate initial production.
- A March 13, 1989, report on technical challenges in developing the AN/BSY-2 concluded that increased Navy management attention should be focused on several areas of risk to keep AN/BSY-2 performance requirements within tight time frames and costs, Submarine Combat System: Technical Challenges Confronting Navy's Seawolf AN/BSY-2 Development (GAO/IMTEC-89-35).
- An April 19, 1990, report on the SSN-21 construction program discussed program status and affordability, Navy Ships: Status of SSN-21 Ship Construction Program (GAO/NSIAD-90-163).
- A January 31, 1990, report on Navy submarine combat systems included the AN/BSY-2 discussed cost increases, schedule slippage, and phased delivery of the first AN/BSY-2's software, Navy Acquisition: Cost, Schedule, and Performance of New Submarine Combat System (GAO/NSIAD-90-72).
- A February 14, 1990, report on advanced submarine technology concluded that a better process had to be established to transfer this technology into current submarine construction programs, Submarine Technology: Transition Plans Needed to Realize Gains From DOD Advanced Research (GAO/IMTEC-90-21).

- April 26, 1990, and May 22, 1990, testimony on the SSN-21 and AN/BSY-2 programs, respectively, detailed concerns GAO had about the affordability and concurrency of these programs, Status of the Navy's New Seawolf Attack Submarine and its New Combat System (GAO/T-NSIAD-90-36) and Navy Ships: Status of SSN-21 and DDG-51 Programs (GAO/T-NSIAD-90-44).
- A July 24, 1990, testimony on the status of the SSN-21-class attack submarine and its new combat system continued to express concerns about affordability and concurrency, Status of the Navy's New Seawolf Attack Submarine and its New Combat System (GAO/T-NSIAD-90-38).
- A September 28, 1990, report discussed the high degree of concurrency within the SSN-21 program, Navy Ships: Concurrency Within the SSN-21 Program (GAO/NSIAD-90-297).
- A May 24, 1991, letter to Representative Herbert H. Bateman discussed cost projections for several SSN-21 procurement scenarios, the impact of reducing the number of SSN-21-class ships on the submarine shipbuilding industrial base, and the cost to construct follow-on SSN-21s.
- A May 24, 1991, briefing report on the status of selected technical risks involved in AN/BSY-2 development pointed out that risks previously identified by the Institute for Defense Analysis remained, and that, if left unresolved, these risks could significantly impair system development through increased costs, schedule delays, and reduced system performance, Submarine Combat System: Status of Selected Technical Risks in the BSY-2 Development (GAO/IMTEC-91-46BR).
- An August 22, 1991, report on AN/BSY-2 development risks concluded that, in its endeavor to meet AN/BSY-2 delivery schedules that are tied closely to the submarine's delivery, the Navy was not following sound management principles and practices that could have resulted in combat systems that were less capable than planned and cost millions to enhance, Submarine Combat System: BSY-2 Development Risks Must Be Addressed and Production Schedule Reassessed (GAO/IMTEC-91-30).
- An April 8, 1992, report on the effects of reduced SSN-21 procurement rates on the submarine shipbuilding industrial base and the cost of the program concluded that (1) an acquisition rate of about one submarine per year would not competitively support two private submarine shipbuilders, (2) termination of the program will accelerate and exacerbate the submarine shipbuilding industry's further deterioration, and (3) SSN-21 class submarine unit end cost will continue to increase, Navy Shipbuilding: Effects of Reduced SSN-21 Procurement Rates on Industrial Base and Cost of Program (GAO/NSIAD-92-140).
- A November 6, 1992, letter to Senator Edward Kennedy and Representative John Conyers discussed the Navy's plans to use \$540.2 million appropriated by Congress for the submarine shipbuilding

industrial base for the SSN-21, Seawolf Contract Terminations
(GAO/NSIAD-93-41R).

- A November 17, 1992, report on the status of the SSN-21 construction program discussed continuing cost and schedule problems, Navy Ships: Status of SSN-21 Design and Lead Ship Construction Program (GAO/NSIAD-93-34).
- A November 27, 1992, briefing report discussed plans and anticipated liabilities to terminate SSN-21 program contracts, Navy Ships: Plans and Anticipated Liabilities to Terminate SSN-21 Program Contracts (GAO/NSIAD-93-32BR).

Subsystem Problems Not Expected to Delay SSN-21's Delivery

Many of the SSN-21 class submarine's major subsystems incorporate technological advances that increase quieting, weapons load, and firing capabilities, and add a new combat system. Of the 10 subsystems¹ we examined, 2 of these—the weapons stowage and handling system and atmosphere control system—are experiencing design, production, or installation schedule problems. According to the SSN-21 program office, Supervisor of Shipbuilding, and shipbuilder officials, the problems are not expected to affect SSN-21 delivery. We also reviewed progress of the AN/BSY-2 combat system. Program office and contractor officials believe that the system will meet its adjusted delivery due to the 1-year delay in the SSN-21's delivery.

Weapon Stowage and Handling System

As of December 1992, late and incomplete design data has caused fabrication of the weapons stowage and handling system to fall 3 months behind schedule. The system was designed by Newport News Shipbuilding and is being built by Electric Boat. Originally, Electric Boat planned to assemble and test the system before installing it on the SSN-21. However, in an attempt to minimize SSN-21 construction delays, Electric Boat plans to build and assemble the system at the SSN-21 principal construction location, partially test the system before installing it, and then fully test the system after the hull sections have been welded together. Electric Boat officials told us that system assembly could be completed, if necessary, after welding was completed and the hull sections were closed, but assembly would be more difficult by doing so. Navy officials believe that, barring any major unforeseen problems, Electric Boat can recover time lost in previous schedule delays on the weapons stowage and handling system while avoiding any adverse effects on the SSN-21's May 1996 delivery.

Atmosphere Control System

Most atmosphere control system components were designed and built for other classes of submarines and require little or no modification for the SSN-21. The atmosphere control system removes atmospheric contaminants that may accumulate in submarine air during long periods under water. All the system's components have been delivered to Electric Boat, with installation originally scheduled to begin between late August 1992 and mid-September 1992.

¹Based on our prior SSN-21 program work, we selected the following 10 major subsystems to review: the ship navigation system, ship service turbine generator, the main propulsion unit, propulsor, ship control system, ship's data distribution system, ship communications system, the AN/BSY-2 combat system, the atmosphere control system, and the weapons stowage and handling system.

Four system components—the oxygen generator, the gas management system, the carbon dioxide scrubbers, and the carbon monoxide burners—scheduled for installation beginning in August 1992 have been delivered to the shipyard. As of December 1992, Electric Boat, however, had not yet begun installing any of these four components on the submarine due to SSN-21 design drawing error, such as mismatched equipment foundation footing. Electric Boat is currently in the process of establishing revised installation dates.

AN/BSY-2 Combat System Delivery Remains a Risk

The potential for late delivery of the first phase AN/BSY-2 combat system capabilities continues. Our November 1992 report noted that delivery of AN/BSY-2 first phase capabilities (all hardware and the majority of software) had been delayed from its November 1993 contract delivery to between late March and June 1994. The primary reasons for the delays were insufficient staffing during the early phase of system development and delays completing a system critical design review. DOD stated that delivery of first phase capabilities is merely a projected delay and is not a contractually authorized change to the delivery schedule.

Since then, the schedule has been extended to reflect stop work orders issued as a result of terminating the SSN-21 program and the SSN-21's revised May 1996 delivery. Under the current plan, first phase capabilities are scheduled for delivery in February 1995; AN/BSY-2 program and contractor officials are confident that first phase capabilities will be delivered in February 1995. In December 1992, however, the Navy reported to DOD that software development continues as the major cost, schedule, and technical risk. As of December 1992, the prime contractor's cost estimate to complete development of the AN/BSY-2 was \$1 billion—\$114 million over the original contract target cost. DOD stated most of this increase is attributable to negotiated contract modifications.

SSN-21 HY-100 Steel Welding Problem Resolved

In June 1991, with construction approximately 16 percent complete, Electric Boat notified the Navy that it had again discovered HY-100 steel weld cracks—this time where two SSN-21 hull rings were joined together.¹ Further investigation revealed additional HY-100 welds displaying unacceptable mechanical properties on the SSN-21's pressure hull and on at least 21 government- and contractor-furnished items. By August 1991, all HY-100 construction welding had been stopped.

Electric Boat concluded that the chemical composition of the welding metal—particularly carbon—in combination with low weld pre-heat and heat inputs had resulted in hydrogen-assisted weld cracking and unacceptable metal yield strengths and ductility. Ultimately, however, the welding cracks were caused by deficient government specifications for welding HY-100 steel. Electric Boat and the Navy assessed the problem and took corrective action; all welding resumed by December 1991. The Navy subsequently paid Electric Boat about \$77.8 million (then-year dollars) to replace all defective HY-100 welding.

Electric Boat has corrected all known SSN-21 HY-100 steel weld cracking problems. Electric Boat, the Navy, and three Navy welding consultants believe that corrective actions taken should prevent the problem from recurring in the future.

By September 1992, Electric Boat had replaced and rewelded all defective welding materials. As of November 1992, no additional HY-100 welding problems had occurred.

To correct HY-100 steel welding deficiencies, Electric Boat and the Navy implemented and tested new welding procedures. The most significant changes included (1) increasing the minimum preheat temperature from 150° F to 225° F, (2) maintaining required cooling rate during the welding process, (3) heating completed welds to 350° F for up to 12 hours to assist in hydrogen diffusion, and (4) using new low carbon content welding wire.

Continuous Navy inspections of SSN-21 HY-100 welding since welding resumed in December 1991 has not disclosed any additional problems. Since corrective actions were implemented, Navy HY-100 production weld incident reports show significant reductions in welding deviations. In addition, Navy Supervisor of Shipbuilding, Conversion, and Repair officials

¹HY-100, a high-yield steel used in the construction of the SSN-21 pressure hull and selected components, allows the submarine to achieve deeper diving depths.

Appendix III
SSN-21 HY-100 Steel Welding Problem
Resolved

in Groton stated that Navy welding process reviews as of the end of November 1992 had not disclosed any welding process problems.

Comments From the Department of Defense



ACQUISITION

OFFICE OF THE UNDER SECRETARY OF DEFENSE

WASHINGTON, DC 20301-3000

24 JUN 1993

Mr. Frank C. Conahan
Assistant Comptroller General
National Security and International
Affairs Division
U.S. General Accounting Office
Washington, D.C. 20548

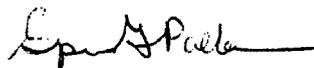
Dear Mr. Conahan:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report entitled-- "NAVY SHIPS: Problems Continue to Plague the Seawolf Program," dated April 13, 1993 (GAO Code 394485/OSD Case 9369). The DoD partially concurs with the report.

The SEAWOLF program continues to progress toward delivery of highly capable attack submarines to the Navy. As the GAO report indicates, while difficulties have been encountered, the ship builder, the design yard, and the Program Manager are actively working (1) to solve problems as they occur and (2) to maintain the delivery schedule for the lead ship.

Some portions of the report focus on unit cost increases that are largely the result of inflation and the sharp reduction in the number of submarines that will be procured. Those are factors beyond the control of the Program Manager. Where appropriate, the detailed DoD comments provide cost comparisons indicative of cost growth not associated with the above factors.

The detailed DoD comments on the report findings are provided in the enclosure. The Department appreciates the opportunity to comment on the draft report.


for Frank Kendall
Director
Tactical Systems

Enclosure

GAO DRAFT REPORT - DATED APRIL 13, 1993

(GAO CODE 394485) OSD CASE 9369

"NAVY SHIPS: PROBLEMS CONTINUE TO PLAGUE
THE SEAWOLF SUBMARINE PROGRAM"

DEPARTMENT OF DEFENSE COMMENTS

* * * * *

FINDINGS

- o **FINDING A: Total Program Costs Decrease While Average Submarine Costs Increase.** The GAO reported that, while truncation of the SEAWOLF program to two ships had reduced total estimated program costs by almost \$34 billion, the average submarine cost has increased by 360 percent. The GAO observed that on May 3, 1991, the Navy awarded General Dynamic Electric Boat Division, Groton, Connecticut, a fixed-price incentive-fee contract to construct the SSN-22, at a cost of \$689 million. The GAO observed that, on March 16, 1992, following the Newport News Shipbuilding and Drydock Company court challenge, the U.S. Circuit Court of Appeals upheld the Navy contract award to Electric Boat. The GAO noted that Electric Boat began SSN-22 construction in September 1992--with contract delivery scheduled for June 1997. The GAO also noted that, because of construction delays, the court challenge, and a Navy stop work order, Electric Boat requested a \$124 million (1987 dollars) increase in the SSN-22 contract target cost and an 18-month delivery date extension to December 1998. The GAO added that the Navy expects to decide on the request sometime during the spring of 1993. (pp. 15-16/GAO Draft Report)

DOD RESPONSE: Concur. Prior to the decision to terminate, the SEAWOLF program consisted of twelve ships. Following termination, the program was reduced to the current two ships. That rebaselining represented a \$23 billion cost reduction. The resulting increase in unit cost is a result of amortizing costs over the two rather than the twelve ship program.

- o **FINDING B: Cancellation of SSN-23 Through SSN-26 Contracts.**
The GAO reported that, in FY 1991, the Congress appropriated \$2.4 billion to construct the SSN-23 and to cover advanced procurement items for follow-on SSN-21 class submarines.

Now on pp. 8-9.

The GAO observed that, until President Bush proposed terminating the program in 1992, the Navy had planned to issue a solicitation for SSN-23 construction during the second quarter of FY 1992. The GAO pointed out that, since then, the Congress rescinded certain funds appropriated for the SSN-23 through SSN-26, and the Navy has either completed, issued stop work orders, or terminated related contracts. (pp. 16-17/GAO Draft Report).

DOD RESPONSE: Concur.

- o **FINDING C: SSN-21 Construction Is Behind Schedule.** The GAO reported that, during the past year, the SSN-21 class design and lead submarine construction efforts continued to suffer schedule problems. The GAO determined the major factors contributing to the construction delays are (1) late delivery of design data, (2) delays preparing and releasing work packages, and (3) a smaller-than-planned construction work force. The GAO observed that as of December 1992, SSN-21 construction had fallen behind the schedule established to meet the revised May 1996 delivery. The GAO also observed that Electric Boat estimated that construction delays amounted to about five months; the Navy estimated the delay at 6 months.

The GAO explained it is the Electric Boat position that the primary factor for SSN-21 construction delays was due to the design effort not fully supporting the construction schedule. The GAO also explained that, since October 1989 (when construction started), the construction schedule had changed four times--the last two changes occurring in March 1991 (Revision D) and November 1991 (Revision E). The GAO further explained Revision E is the current construction schedule that supports the May 1996 delivery of the submarine. The GAO learned that Electric Boat had expressed its concerns about the effects of late design data to the Navy on a number of occasions from June through November 1992. In addition, the GAO reported, construction problems have also contributed to schedule delays--such as ripping out and re-doing construction. (p 6, pp. 21- 24/GAO Draft Report)

DOD RESPONSE: Partially concur. While late design delivery is a factor in SSN-21 construction delays, other factors are also involved--including (1) contractor manning levels, (2) work package preparation difficulties, and (3) material supply delays. While progress through December 1992 is behind the schedule to support the planned delivery date

Now on p. 9.

Now on pp. 3-4, 12-14.

of May 1996, Electric Boat and the Navy have instituted steps that maintain the schedule and preserve the current delivery date. The shipyard and the Program Manager fully expect to support a May 1996 delivery.

- o **FINDING D: Work Package Preparation Delays.** The GAO reported that Electric Boat has experienced delays preparing and releasing work packages needed to start construction and fully support the Revision E construction schedule. The GAO observed that, as of December 1992, more than 4,100 (5 percent) of the work packages scheduled for completion and 6,100 (9 percent) of the completed work packages scheduled for release to construction workers were delinquent. The GAO explained that preparation problems resulted from insufficient staff, while late release of completed work packages resulted from a process problem. The GAO noted that Electric Boat had taken several measures to improve the timely development of work packages--i.e. increasing staff (from 53 to 78 people), working overtime (35 percent for 2.5 months), and installing 17 additional terminals.

The GAO also explained the primary reason for the high delinquency rate releasing packages was that, under the original manufacturing resource plan, completed work packages would not be released until all elements of the work package were available. The GAO observed that, to address the problem, Electric Boat modified the system--now, if one piece of material was not available (either because it had not been delivered by a vendor or was still in the manufacturing process), the work package is released so other work can be started, with the missing material component installed when it becomes available. The GAO concluded that change is the primary reason for the improvement in the work package release rates. (pp. 6-7, pp. 24-26/GAO Draft Report)

DOD RESPONSE: Partially concur. The work package preparation process begins when planners take the design and package it into a set of instructions that the workers can understand. The required materials are then assembled and tested as necessary. The work is then released to the workers who, in turn, perform and complete the task. Since June 1992, the delinquent percentage of work packages completed or scheduled for release has decreased significantly. The draft report also implies that the sole reason for reduced contractor manning is delinquent work package issue. Delays in the receipt of material on order also contributed

Now on pp. 3-4, 14-15.

to delays in starting work, which subsequently caused the contractor to reduce his manning.

- o **FINDING E: Insufficient Number of Construction Workers Used by Electric Boat.** The GAO observed that the size of the SSN-21 construction work force had consistently been smaller than planned under the Revision E construction schedule, causing less work to be performed. The GAO noted that, since November 1991 (when the Revision E construction schedule was approved) through December 1992, the understaffing percentages averaged about 28 percent below planned levels--ranging between an August 1992 high of 49 percent and a December 1992 low of 26 percent. The GAO also noted that, since as early as June 1992, the Navy had been concerned with the size of the construction work force.

The GAO indicated that, according to the Electric Boat SSN-21 program manager, the primary reason for a smaller-than-planned construction work force had been the unavailability of required design data. The GAO observed that, as Electric Boat reduced work package delinquencies, it became obvious that:

- the receipt of design drawings was not supporting planned work force levels;
- because of late design data, Electric Boat could not implement its plan to correct understaffing by the end of 1992; and
- to minimize unnecessary rework and labor inefficiencies, Electric Boat commits construction personnel only to work where the requisite design data and material are available. (p. 6, pp. 26-28/GAO Draft Report)

DOD RESPONSE: Partially concur. Factors affecting the level of manning of SSN-21 construction, beyond the availability of design data, include (1) material availability, (2) work package procedures, and (3) manning of other ships under construction. There are sufficient personnel available to complete the ship on schedule.

- o **FINDING F: Incompatibility Between Design And Construction Schedules.** The GAO reported that, since November 1991, the design effort had been directed toward meeting the Revision

Now on pp. 4, 15-17.

D construction schedule, while the construction effort was directed towards meeting the current Revision E construction schedule. The GAO noted the SSN-21 program manager decision to require the design effort to adhere to Revision D was made so as to avoid staffing level changes and cost increases that would have resulted from a schedule realignment. The GAO concluded, however, that by March 1992 it became evident the design data was not being provided in time to provide full support for every modular construction activity--and actions were taken to correct the problem (i.e., increasing management overview and conducting monthly planning meetings with all participants).

The GAO reported that, in December 1992, the SSN-21 program manager directed Newport News Shipbuilding to bring its design effort in line with the Revision E construction schedule. The GAO observed that, according to the SSN-21 program manager, the design effort is now in line with the Revision E construction schedule and all design drawing delinquencies will be eliminated by July or August 1993. The GAO added the SSN-21 program manager had agreed that the SSN-21 program office should have monitored the design and construction schedules more aggressively. (pp. 7-8, pp. 28-31/GAO Draft Report)

DOD RESPONSE: Partially concur. The draft report describes the Revision D and Revision E schedules as "incompatible." That terminology is inappropriate. While the two schedules were different, conducting the design with the Revision D schedule did not preclude construction to the Revision E schedule. The GAO references to the term "incompatibility" should be changed to "variance" throughout the report. While some problems may have occurred by retaining the Revision D schedule at the Lead Design Yard, the overall progress achieved on the design outweighs the problems identified. A disciplined process to identify updated drawing needs of the shipbuilder was initiated following adoption of Revision E. The DoD does not agree that the SSN-21 Program Manager should have monitored the design and construction more aggressively--the schedules were, in fact, very closely monitored by the Program Manager.

- o **FINDING G: Actions to Deliver the SSN-21 on Schedule.** The GAO reported that, in September 1992, Electric Boat implemented various actions so as to overcome the 5-month construction delay and meet the May 1996 delivery date. In

Now on pp. 4, 17-19.

table 2.3 of the report, the GAO displayed the actions taken by Electric Boat to work around construction scheduling problems. In addition, the GAO noted that Electric Boat implemented several additional measures to overcome construction delays, such as the following:

- working 3 shifts, 7 days a week, on critical path items;
- working 48 hours per week for trade workers and support personnel; and
- recalling 144 workers and hiring 58 new workers;

The GAO also observed that Electric Boat is in the process of reworking its construction schedule so as to increase the amount of construction work at its Quonset Point, Rhode Island, facility--allowing some functions to be performed earlier and concurrently rather than sequentially (i.e., component/system testing, greater amount of hull section outfitting, and installation of propulsion plant components). The GAO noted that, as a result, the SSN-21 Program Manager believes the SSN-21 May 1996 delivery schedule will be maintained. (p. 8, pp. 31-33/ GAO Draft Report)

DOD RESPONSE: Concur. The Navy aggressively monitored the design and construction efforts. It was through aggressive Navy monitoring that the problems were identified, acted on, and resolved.

- o **FINDING H: Design Costs Will More Than Double.** The GAO reported that, in April 1987, the Navy awarded Newport News Shipbuilding a \$303 million (FY 1987 dollars) cost-plus fixed-fee contract for overall SSN-21 class design and detailed design of its forward half. The GAO also reported that, as part of its design contract, Newport News awarded Electric Boat a \$48.8 million cost-plus fixed-fee subcontract for the detailed design of the submarine rear half. The GAO observed that, since award of those contracts, design costs have increased dramatically: as of December 1992, Newport News Shipbuilding estimated the total cost of the design is expected to be about \$683 million when completed, a \$28 million increase (4 percent) since December 1991 and a \$380 million increase (125 percent) over the original contract cost estimate of \$303 million.

Now on pp. 4, 19-20.

The GAO explained that, according to the Navy, the unexpected complexity of incorporating modular construction concepts into the design, the unexpected higher cost of two shipyards concurrently designing the SSN-21 class, and the cost of implementing advanced computer-aided design methods for modular construction continue to contribute to most of the SSN-21 class design cost increases. The GAO further explained that the following three additional factors also contributed to the cost increases:

- specification changes;
- increased labor hours; and
- incompatible design and construction schedules.

The GAO concluded that, under the terms of the contract, the Government will pay Newport News Shipbuilding for all allowable costs for those increases, plus a fee. (pp 8-9, pp. 35-38/GAO Draft Report).

DOD RESPONSE: Partially concur. As stated in the DoD response to the May 1992 GAO final report on the SSN-21 (GAO/C-NSIAD-92-11/OSD Case 8858-AX), the initial design contract of \$303 million represented an estimate of the design effort required, based on experience with prior programs. The scope of the required effort proved to be larger due to several factors, including (1) the complexity of introducing modular construction concepts, (2) implementation of advanced computer-aided design methods, and (3) the cost of obtaining equipment to meet the SSN-21 performance requirement.

The draft report consistently compares the latest revised contractor estimate to the original basic contract. Such a comparison does not adequately reflect the fact that the SEAWOLF Program Manager rebaselined the detail design contract on June 20, 1990. As a result, the comparisons in the draft report are not representative of the current contractual agreement with the lead design yard. Relative to the rebaselined contract, the current estimated cost of \$649.5 million (current year dollars) represents an increase of 22 percent.

- o **FINDING I: Construction Costs Will Increase More Than 50 Percent.** The GAO reported that, in January 1989, the Navy awarded Electric Boat a \$718 million (then-year

Now on pp. 4-5, 21-23.

Now on pp. 4-5, 23-25.

dollars) fixed-price incentive-fee contract to build the SSN-21. The GAO noted that, since then, construction costs have increased significantly. The GAO observed that, as of December 1992, Electric Boat estimated that the total cost of SSN-21 construction will rise to about \$1,103 million-- a \$64 million (six percent) increase since December 1991 and a \$385 million (54 percent) increase over the original contract cost estimate. The GAO explained that the \$64 million increase since December 1991 consists of (1) \$15 million for contract changes, (2) \$30 million for increased labor rates, and (3) \$19 million for increases in material cost estimates at completion. (pp. 8-9, pp. 38-40/GAO Draft Report)

DOD RESPONSE: Partially concur. The draft report incorrectly compares the initial contract target price (not adjusted for inflation), with the current contractor estimate. In order to calculate percentage cost increases a common year for all dollar figures must be used to add or subtract inflation related differences. The \$718 million is not adjusted for inflation. A more accurate comparison is to compare the \$718 million (1987 dollars) with \$974.7 million (\$1,103 million adjusted to 1987 dollars), which is an increase of \$256.7 million (35 percent) over the original contract target price and a \$32 million (3.3 percent) increase from December 1991. Over half the 35 percent growth is due to the cancellation of the outyear SEAWOLF submarines and the impact of Stop Work Orders.

- o **FINDING J: Subsystem Problems Not Expected to Delay SSN-21 Delivery.** The GAO reported that many of the major subsystems of the SSN-21 class submarine incorporate technological advances, which give the submarines increased quieting, greater weapons load, and greater firing capabilities--as well as a new combat system. The GAO observed that two of the ten subsystems it examined--weapon stowage and handling system and atmosphere control system--are experiencing design, production, or installation problems. The GAO also reviewed progress of the AN/BSY-2 combat system. The GAO observed that, according to program office and contractor officials, all three systems will meet the May 1996 adjusted delivery date.
- **Weapon Stowage and Handling System--**The GAO reported that, as of December 1992, late and incomplete design data has caused fabrication

of the weapons stowage and handling system to fall 3 months behind schedule.

- Atmosphere Control System--The GAO reported that the four system components scheduled for installation in August 1992--the oxygen generator, the gas management system, the carbon dioxide scrubbers, and the carbon monoxide burners--have been delivered to the shipyard, but as of December 1992, Electric Boat had not begun installing any of the four components on the submarine due to SSN-21 design drawing errors.
- AN/BSY-2 Combat System--The GAO reported that delivery of AN/BSY-2 first-phase capabilities (all hardware and the majority of software) had been delayed from its November 1993 contract delivery to between late March and June 1994 due to insufficient staffing during the early phase of system development and delays completing a system critical design review. The GAO observed that, as of September 1992, the cost estimate to complete development of the AN-BSY-2 was \$995 million--\$105 million over the original contract target cost. (pp. 47-50/GAO Draft Report)

DOD RESPONSE: Concur.

- o FINDING K: SSN-21 HY-100 Steel Welding Crack Problem Resolved. The GAO reported that, in June 1991, with construction approximately 16 percent complete, Electric Boat notified the Navy it had again discovered HY-100 steel weld cracks--this time where two SSN-21 hull rings were joined together. The GAO also reported that further investigation revealed additional HY-100 welds displaying unacceptable mechanical properties on the SSN-21 pressure hull and on at least 20 Government- and contractor-furnished items. In addition, the GAO reported that Electric Boat determined the chemical composition of the welding metal--particularly carbon--in combination with low weld heat had resulted in hydrogen-assisted weld cracking and unacceptable metal yield strengths and ductility. The GAO observed that the Navy subsequently paid Electric Boat about \$77.8 million (in then-year dollars) to replace all defective HY-100 welding.

Now on pp. 29-30.

Now on pp. 31-32.

The GAO found that, by September 1992, Electric Boat had corrected the welding problem and instituted new procedures, which included (1) raising preheat and post weld temperatures, (2) increasing the heating time for completed welds to "burn off" impurities, and (3) using welding wire containing less carbon. The GAO reported that, according to Electric Boat officials, Navy officials, and three welding consultants, the new welding procedures have resolved the welding problem and should prevent its reoccurrence.
(p. 9, pp. 51-53/GAO Draft Report)

DOD RESPONSE: Concur.

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